Lessons from Large Scale CO_2 Injection

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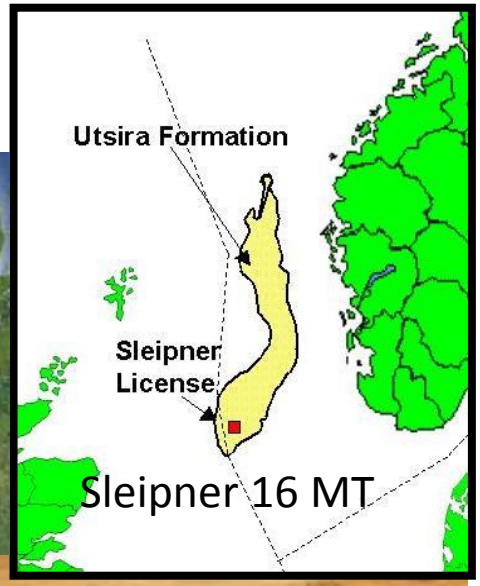
Snohvit 1.5 MT



Sleipner 16 MT

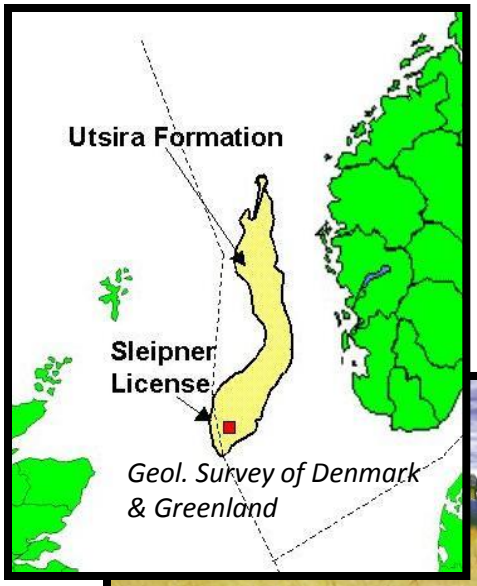

In Salah 3.8 MT

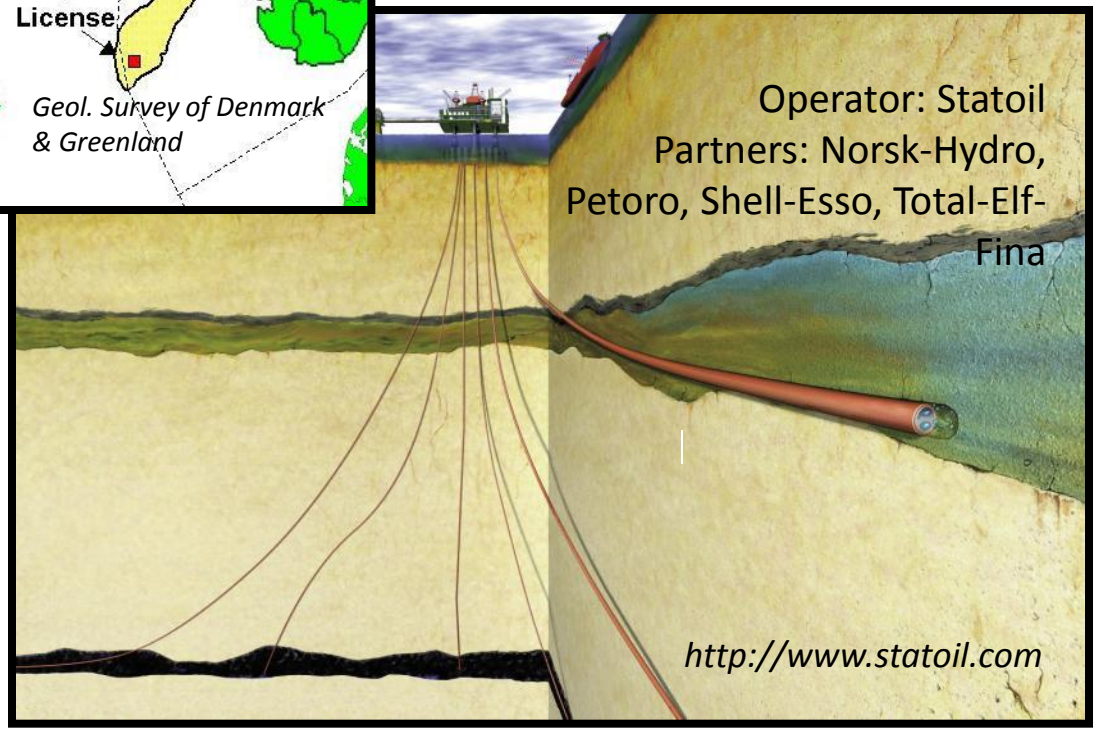
Fifteen Years of Large Scale Injection. What have we learned?

- Safe, economical storage is practical.
- Geochemistry is insignificant on this time scale.
- Geomechanics is extremely important.

Sleipner Vest project demonstrates 1st order viability of commercial storage

FIRST large volume CO_2 sequestration, offshore Norway. Active since 1996



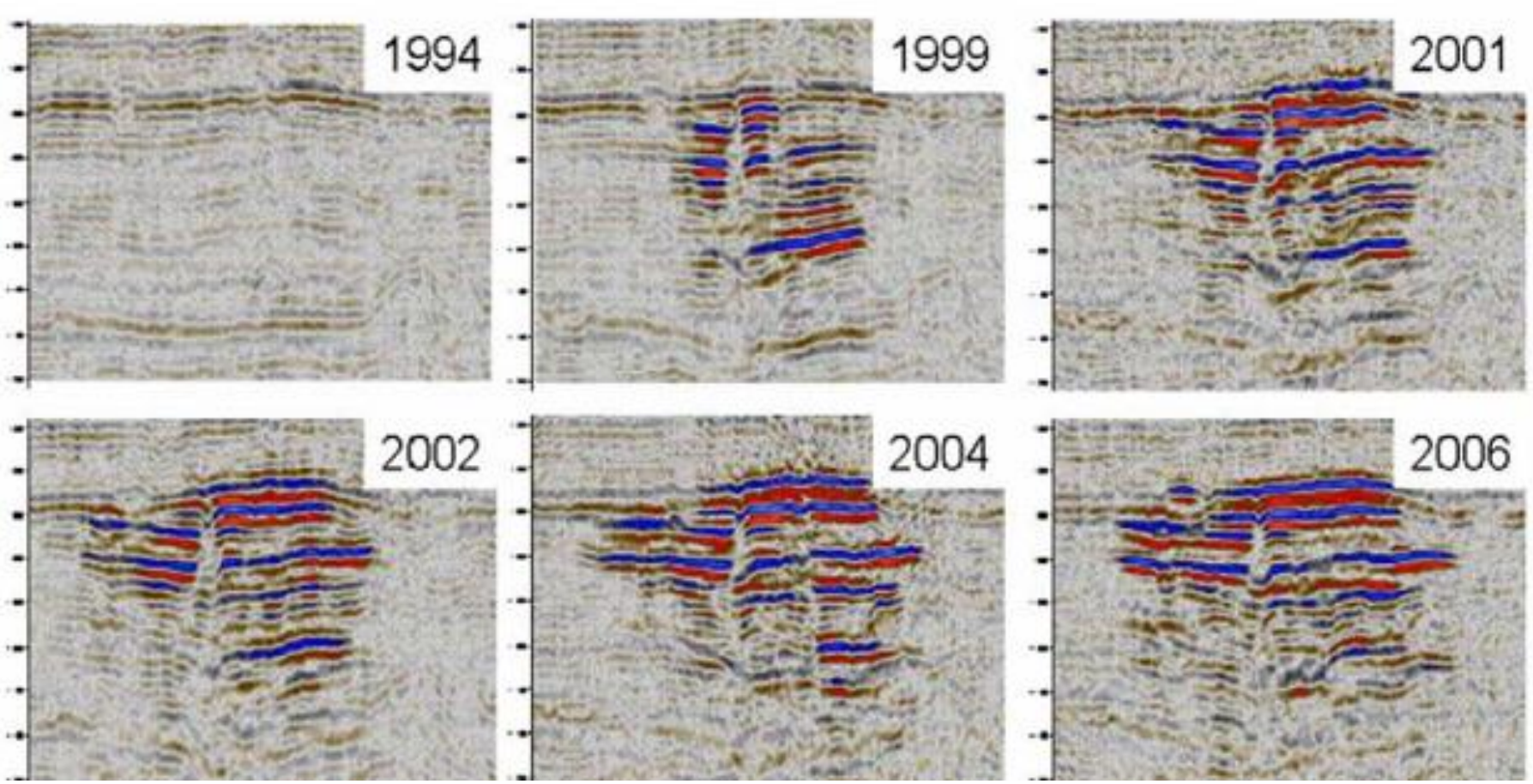


Target: 1 MM t CO_2/yr.
So far, 16 MM t

Miocene Aquifer: DW fan complex

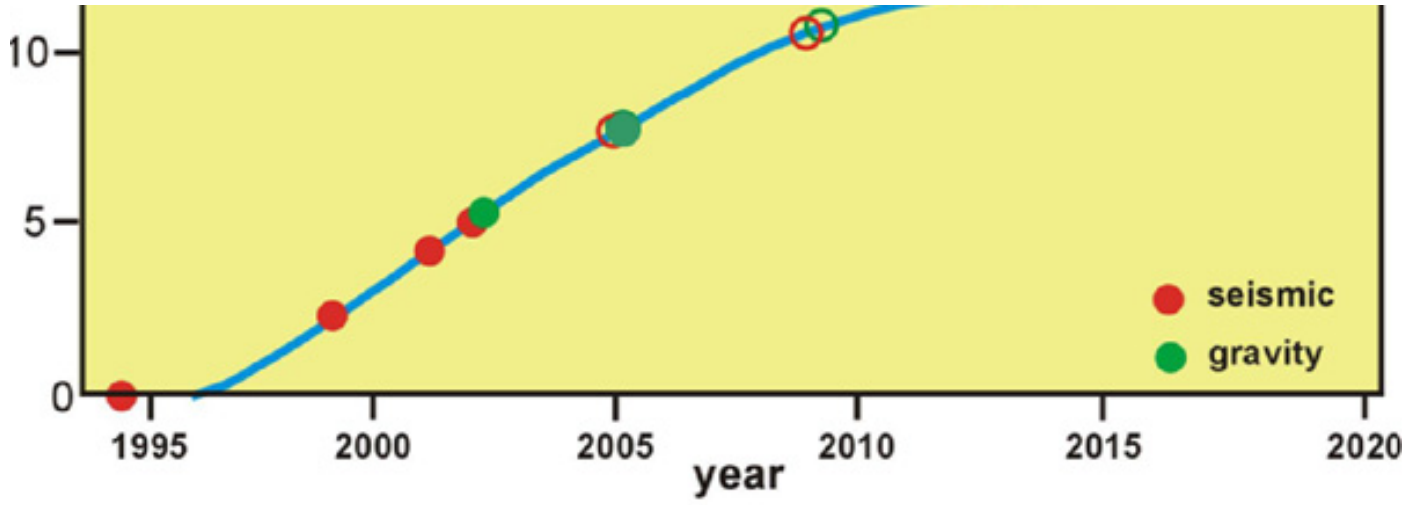
- 30-40% porosity, 200 m thick
- high perm. (~3000 mD)

1st Learning: Segmentation is important even in a permeable sandstone

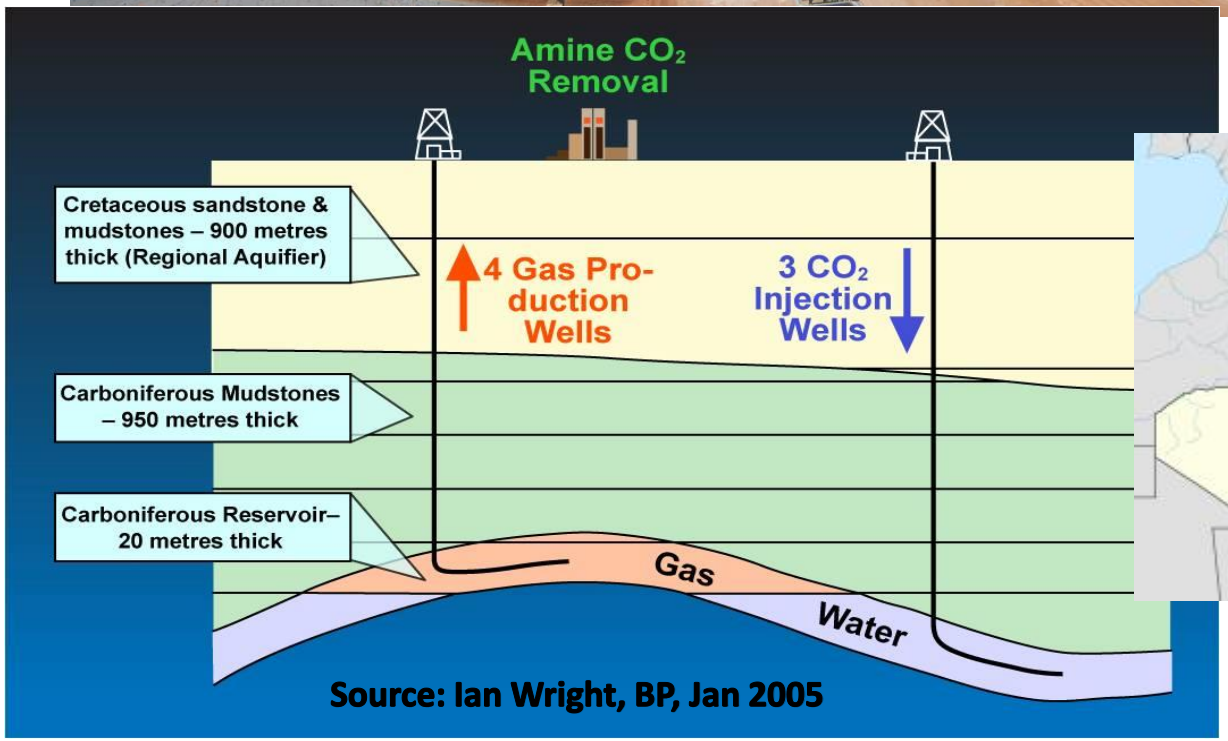


Sleipner was good start.

- No leakage
- Continuous operation
- 4-D seismic monitoring very accurate



In Salah, Algeria: 1 M t/yr CO_2 separated from produced gas was injected into aquifer below gas zones



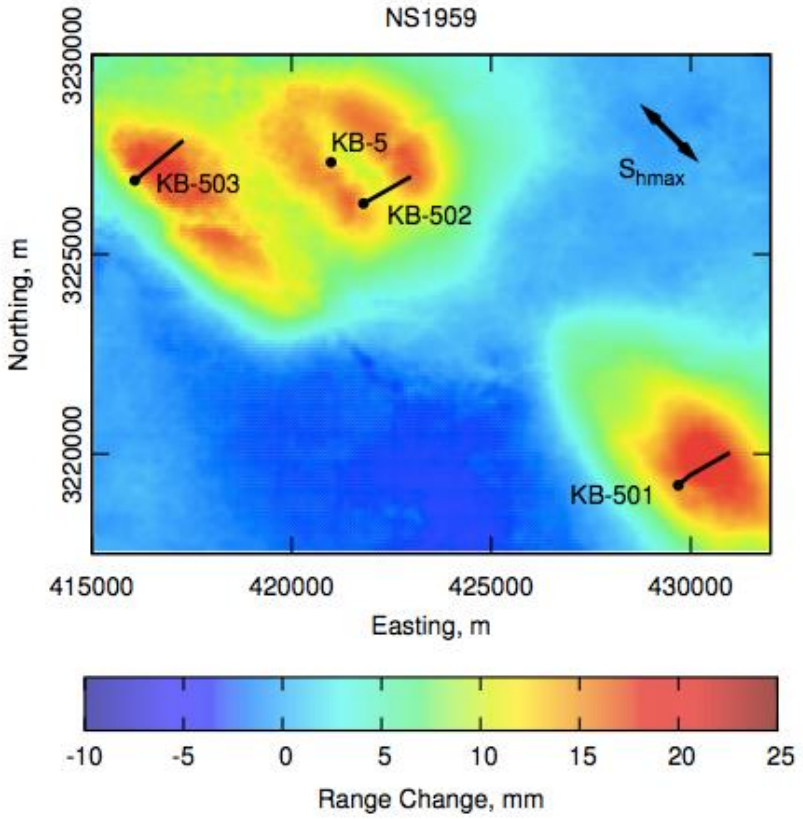
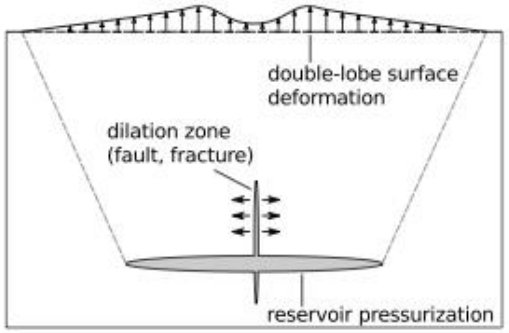


Fig. 3. InSAR measured surface deformations as of March 2010.



But satellite measurements immediately indicated an issue

2nd Learning: Geomechanics is important.

- Good monitoring was effective at In Salah.
- No leakage has taken place.
- Operations now complete.

Back to Off Shore – Snohvit

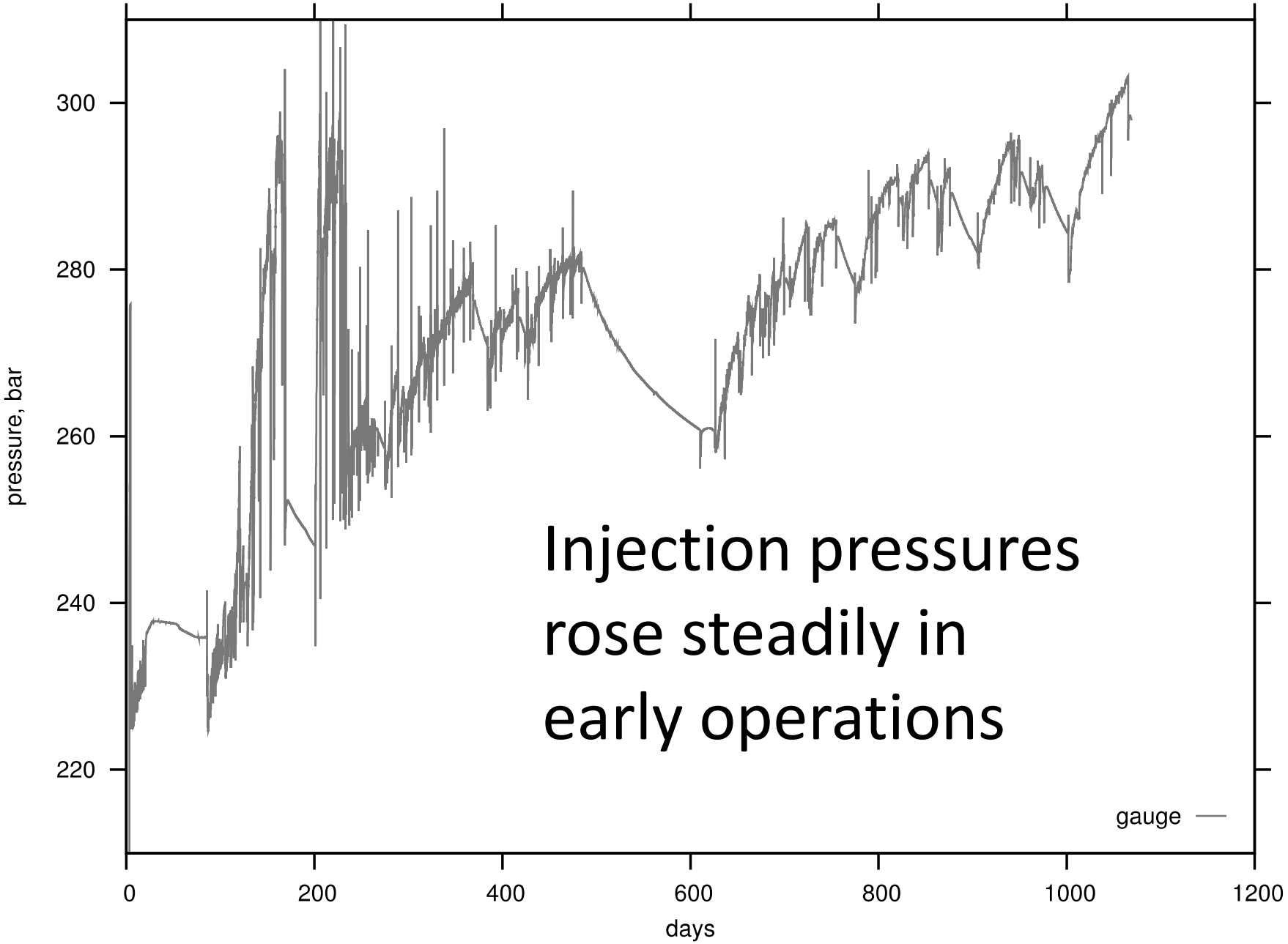


Figure Permanent pressure sensor at 1782 mTVDss, hourly data.

4-D Seismic Indicated Channels

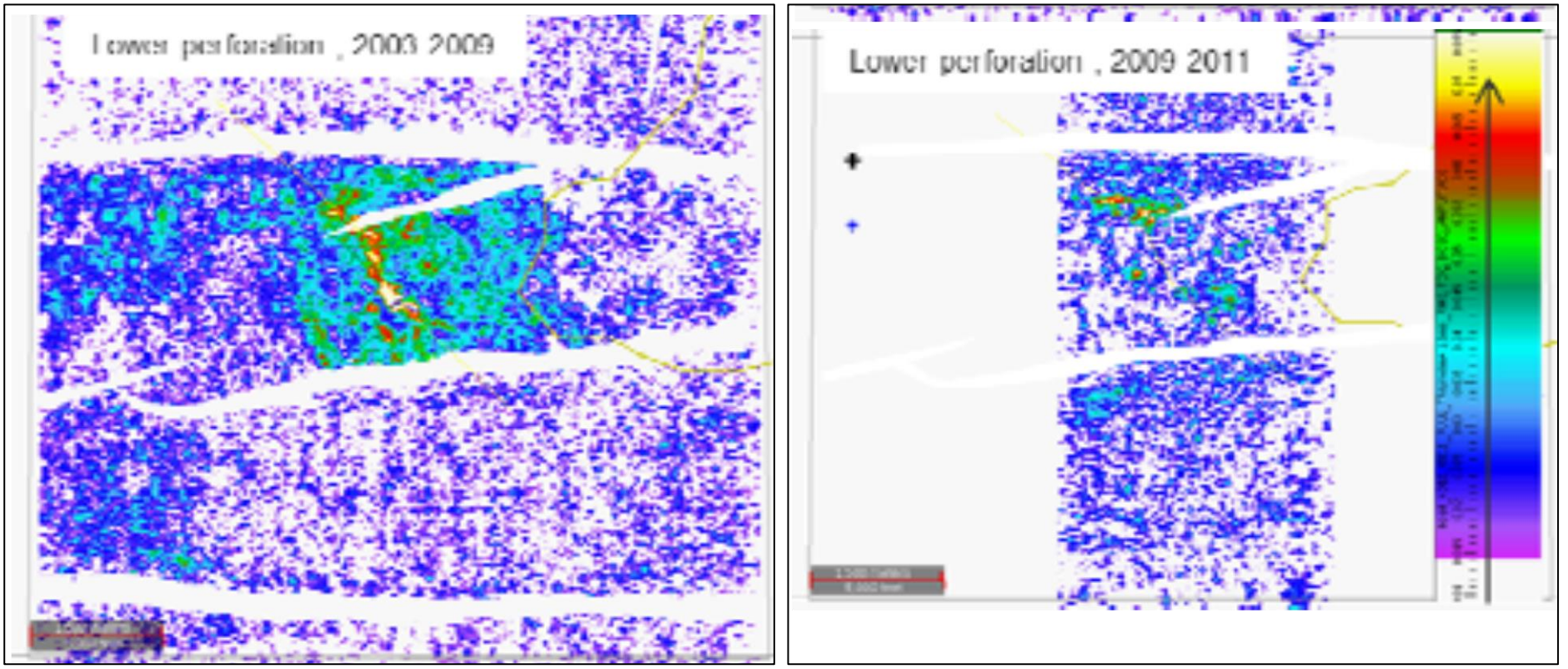


Figure: 4D difference amplitude maps, lower perforation, from (Hansen et al, 2012). Left: 2003-2009, Right: 2009-2011.

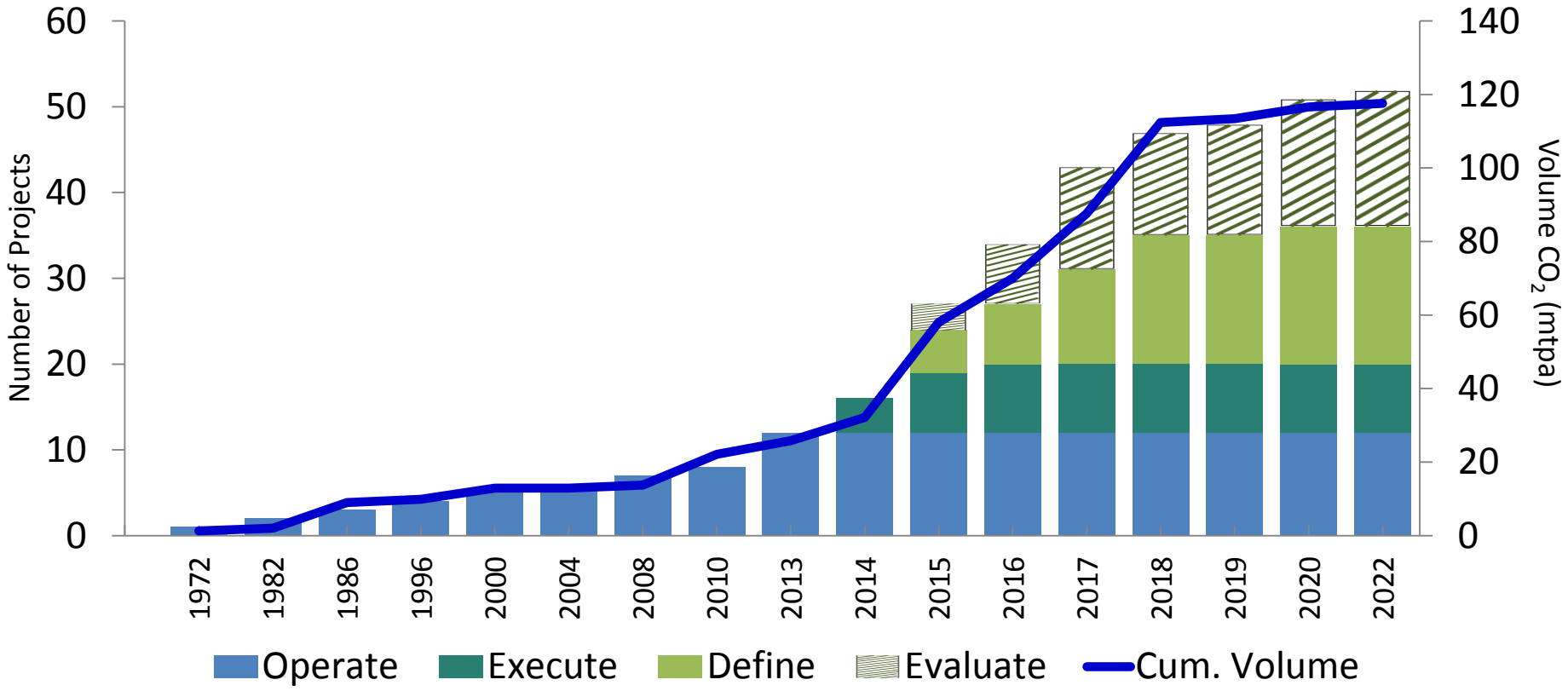
- 4D seismic reveals distinct channels and vertical stratification.
- Lower perforation taking ~80% of the injection.

1st Learning Repeated

- Flow is channelized
- In this case, restrictions limited injectivity
- Well was recompleted in a higher unit, which now takes CO_2 without any pressurization.

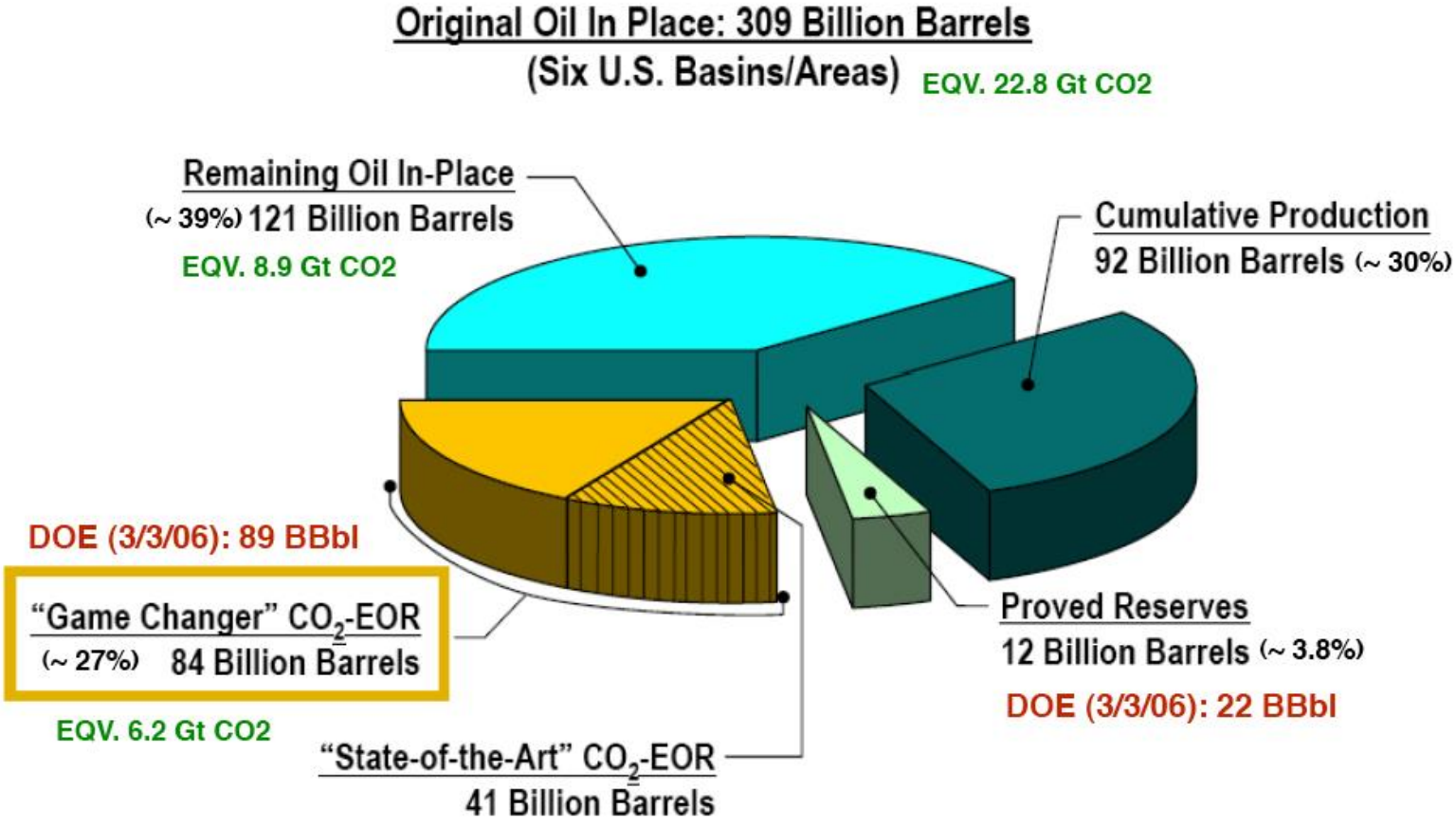
Why aren’t there more large demonstrations?

Large Scale Integrated Projects World Wide



Data from Global CCS Institute

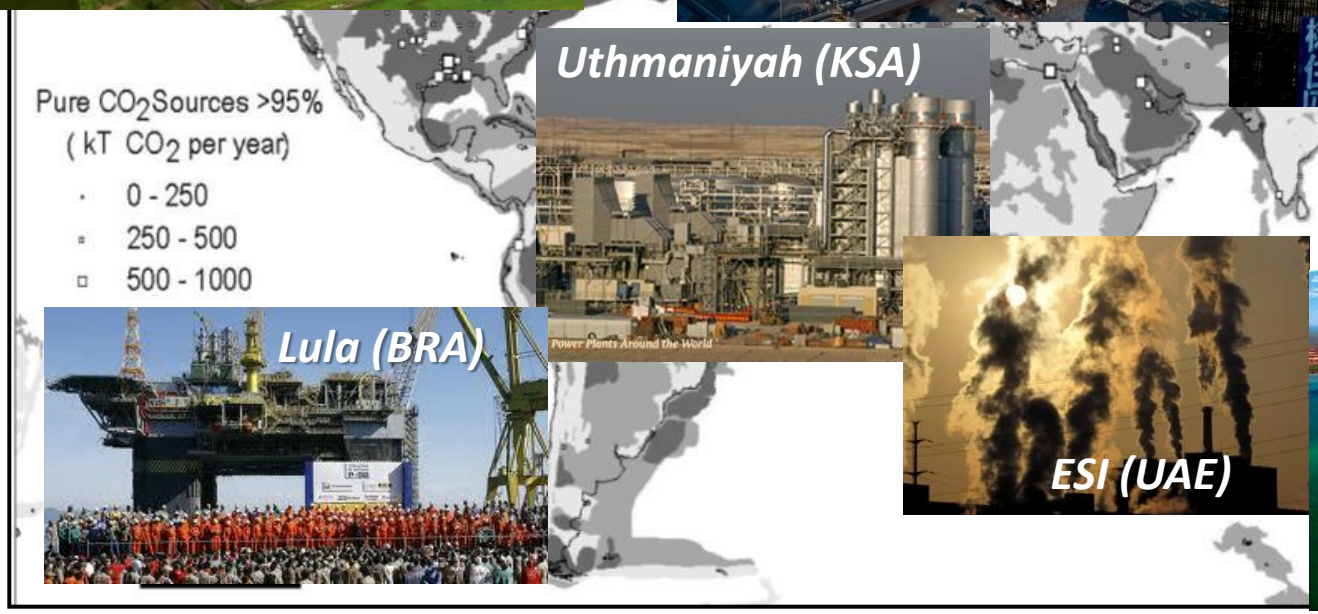
CO_2 EOR could double the *cumulative* oil production of the



EQV. Equivalent volume

Advanced Resources International, 2005

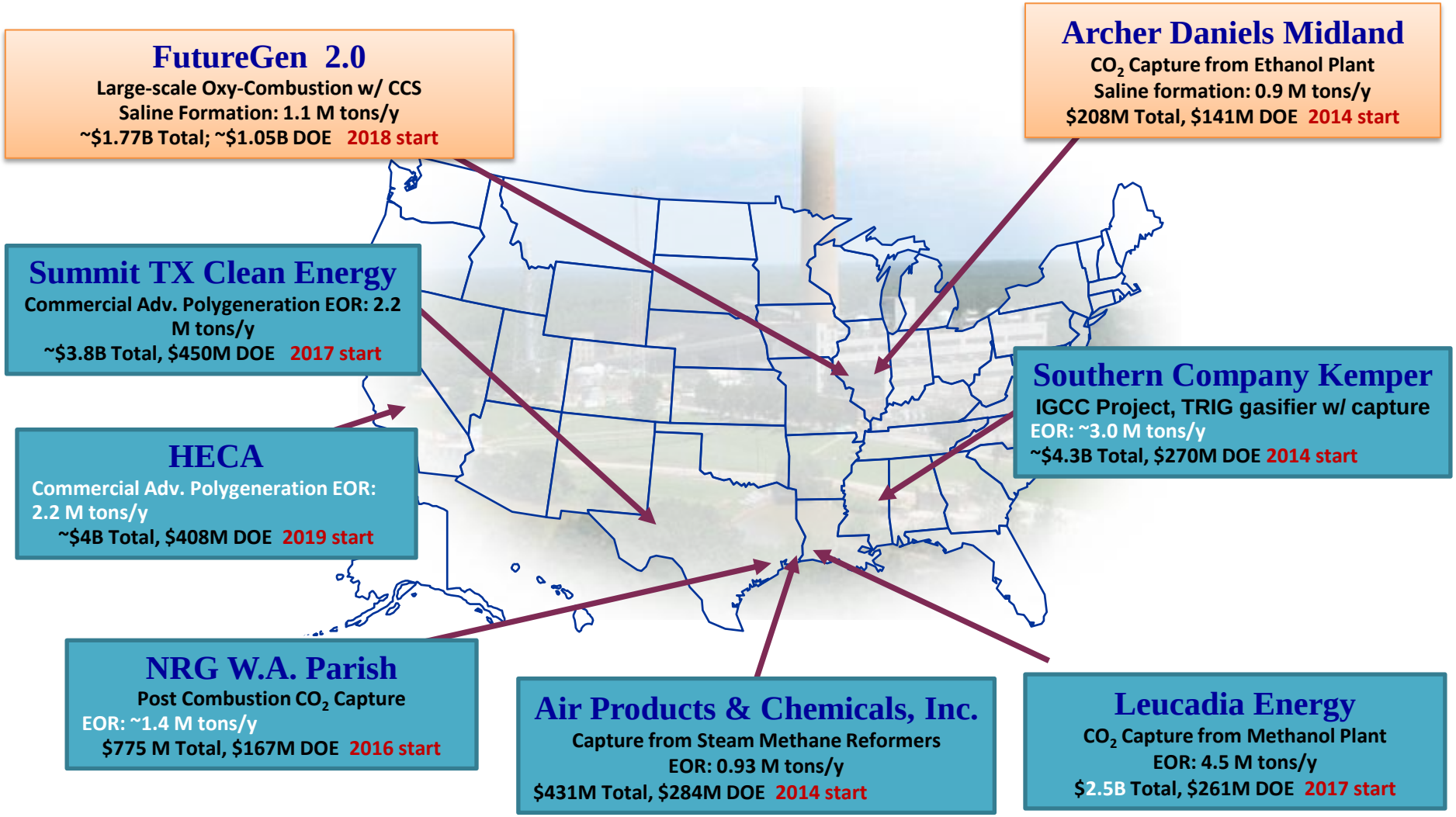
Global challenge ⇒ global progress: new global solutions still required



We just need more projects and more information

$30/tonne approximate value

Major US CCS Demonstration Projects Will Feed CO_2 into EOR Efforts



FutureGen 2.0
Large-scale Oxy-Combustion w/ CCS
Saline Formation: 1.1 M tons/y
~$1.77B Total; ~$1.05B DOE 2018 start

Archer Daniels Midland
CO_2 Capture from Ethanol Plant
Saline formation: 0.9 M tons/y
$208M Total, $141M DOE 2014 start

Summit TX Clean Energy
Commercial Adv. Polygeneration EOR: 2.2 M tons/y
~$3.8B Total, $450M DOE 2017 start

Southern Company Kemper
IGCC Project, TRIG gasifier w/ capture
EOR: ~3.0 M tons/y
~$4.3B Total, $270M DOE 2014 start

HECA
Commercial Adv. Polygeneration EOR: 2.2 M tons/y
~$4B Total, $408M DOE 2019 start

NRG W.A. Parish
Post Combustion CO_2 Capture
EOR: ~1.4 M tons/y
$775 M Total, $167M DOE 2016 start

Air Products & Chemicals, Inc.
Capture from Steam Methane Reformers
EOR: 0.93 M tons/y
$431M Total, $284M DOE 2014 start

Leucadia Energy
CO_2 Capture from Methanol Plant
EOR: 4.5 M tons/y
$2.5B Total, $261M DOE 2017 start